

geological estimates as 300,000,000 years for the 'denudation of the Weald'? Whether is it more probable that the physical conditions of the sun's matter differ 1000 times more than dynamics compel us to suppose they differ from those of matter in our laboratories; or that a stormy sea, with possibly channel tides of extreme violence, should encroach on a chalk cliff 1000 times more rapidly than Mr. Darwin's estimate of one inch per century?"¹

But granted that the geological evidence is against the gravitation theory, it remains for us to see how Dr. Croll's theory bears the strain put upon it when the details of the evolutionary processes are inquired into.

According to the impact theory of Dr. Croll, "meteorites are but the fragments of sidereal masses which have been shattered by collision" (p. 12). The result of such a collision would be mainly to produce a gaseous mass, but some of the exterior fragments would have velocities sufficient to carry them beyond the influence of the central mass. This view is obviously in direct contradiction to the opinion held by Mr. Lockyer, who looks upon meteorites as the parents, and not the children, of sidereal systems. The explanation of the thumb-marks and the heterogeneous structure of meteorites which has been given by Mr. Lockyer (Proc. Roy. Soc., vol. xliii. p. 151) would apply equally to Dr. Croll's view.

Comets, according to the impact theory, have a similar origin to meteorites, Dr. Croll apparently agreeing that they are nothing more than swarms of meteorites. Those with elliptic orbits probably had their origin in the collision which produced the nebula out of which the solar system has been evolved, whilst those with parabolic and hyperbolic orbits are probably the outcasts of other systems.

The first condition of a nebula, according to Dr. Croll, is that in which it consists of broken fragments scattered through a gaseous mass of excessively high temperature. Mr. Lockyer's recent researches are consistent with this view, as far as meteorites and interspaces are concerned, but they point to the opposite conclusion with regard to temperature. Mr. Lockyer's spectroscopic work has shown that the highest temperature is in all probability only reached by a nebulous mass after the complete volatilization of all the meteorites composing it, and he has shown that the intermediate stages which should occur on this supposition are actually represented amongst the stars, the stars of Group II. being amongst these. This therefore furnishes a strong argument against the high-temperature theory of nebulae.

According to the impact theory of Dr. Croll, the meteorites scattered through the gaseous mass have nothing whatever to do with the luminosity; whereas, from Mr. Lockyer's point of view, the luminosity is in great part, if not entirely, due to collisions between the meteorites. Dr. Croll objects to this latter view because it "does not appear to afford any rational explanation of this banging about of the stones to and fro in all directions; for, according to it, the only force available is gravitation, and this can only produce merely a motion of the materials towards the centre of the mass" (p. 20). Dr. Croll has evidently given but little thought to this theory, originally advanced by Prof. Tait, for it is obvious that all the meteorites would not lose all their momentum

by collisions during their first movements towards the common centre of gravity. Those which escaped collision would move on beyond the centre of gravity with considerable velocities, and would continue to oscillate to and fro until all their momentum was converted into heat by collisions. The banging about might therefore go on for a very long time, and the observations made by Dunér, and classified by Mr. Lockyer, show that this is probably the case. The increase of temperature would accordingly take place gradually, and not suddenly, as Dr. Croll supposes; and further, the highest temperature would be associated with a certain class of stars, and not with the nebulae themselves.

The subject of new stars is dismissed with very few words. The general view adopted by Dr. Croll seems to be that in such a case as Nova Cygni the outburst was due to the collision of a star with a swarm of meteorites. The spectroscopic evidence in favour of Mr. Lockyer's view, that such an outburst is due to the collision between two swarms of meteorites, is not even referred to. The case of Nova Cygni, indeed, has an important bearing on theories of cosmogony. Its spectrum, as observed by Copeland when it was just fading from our view, was that of a planetary nebula. If, therefore, a nebula is at a higher temperature than a star, Nova Cygni must have got hotter as it got dimmer!

Dr. Croll shows that his theory explains other details of the structure of our universe, including the proper motions of stars and the origin of binary systems, but these need not be more than mentioned.

Assuming that Dr. Croll has established that gravitation alone would have been incompetent to produce the heat originally possessed by the solar nebula, it is only necessary to reconcile this with the low-temperature theory of nebulae, as the high-temperature theory has been shown to be inconsistent with the facts.

It may be suggested that instead of the dark stellar masses endowed with motion which Dr. Croll supposes to have been the pre-nebular condition, meteorites at great distances apart were endowed with similar velocities. In the first groupings, the collisions would only occur very rarely, and there would be more grazes than anything else, so that the average temperature might still be low in the earlier stages. Prof. G. H. Darwin¹ has recently shown that the conception of fluid pressure which is demanded by Laplace's nebular hypothesis is not difficult to reconcile with the meteoritic hypothesis. If we substitute meteorites in collision for the molecules of a gas impinging against each other, there would be a quasi-fluid pressure as the average result of the impacts of the meteorites, and the separation of the planets from the meteor-swarm would take place exactly as in a gaseous mass.

A. FOWLER.

THE TELEPHONE.

The Telephone. By William Henry Preece, F.R.S., and Julius Maier, Ph.D. Pp. i-xvi., and 1-498. (London: Whittaker and Co., 1889.)

THIS book is one of the "Specialists' Series" of technical manuals now being issued by Messrs. Whittaker and Co. Its aim is to give as full an account as possible

¹ *Macmillan's Magazine*, March 1862; reprinted in "Popular Lectures and Addresses," p. 361 (Macmillan, 1889).

¹ Phil. Trans., vol. cclxxx. pp. 1-69.

of telephony as a practical art, and the authors have certainly succeeded in inclosing within the compass of a handy octavo volume a vast amount of well-arranged information on a subject hitherto unrepresented in English by any systematic treatise. After two chapters, comprising about twenty pages, on sound and speech, and on such parts of electrical theory as are more immediately connected with the action of the telephone, the authors proceed to deal with the construction of the telephone, and treat in detail the subject of transmitters and receivers of all kinds. This part of the book is very interesting, giving as it does an account of the principal forms of telephone receivers and transmitters which were the outcome of the marvellous activity of telephonic research aroused by the publication of the inventions of Bell, Edison, and Hughes. In chapter x. come telephone lines and cables, and modes of installing them; then chapters on auxiliary apparatus, and on terminal and intermediate stations, lead up to the important subject of telephone exchanges, and appliances connected with their working, to which chapters xiv. to xx. are devoted. Long-distance telephony is introduced in chapter xxi., and systems of translation between the terminal networks, and the return wire or other induction avoiding circuit between the two places, are fully described. Various problems of practical telephony are then discussed, such as multiplex telephony, and the numerous devices for enabling several subscribers to work in one circuit. Chapters on the telephone as applied to the telegraph service, its military uses in camp and in the field, and finally some miscellaneous although important scientific applications of the instrument, conclude the work.

Of the main body of the work the contents of which are briefly analyzed above, we have no remark to make that is not commendatory. As has been already indicated, the work is full of most valuable practical details of actual working systems of telephony. The descriptions of complicated apparatus and appliances are full and clear, and bear everywhere the stamp of the work of men accustomed to exposition, and professionally acquainted with the subjects of which they treat.

In our examination of the work, we have noted a few points in which perhaps improvement might be effected in a second edition. Most of these occur in the preliminary chapters on the theory of the telephone, a part of the subject in some ways much more difficult to treat successfully than that which follows. For example, such a phrase as that on p. 14—that in a current following the simple harmonic law of variation with the time the electricity flowing is, “so to speak, thrown into undulatory motion”—is very apt to create an erroneous impression on the mind of a learner, and in no way describes what actually takes place. What is thrown into undulatory motion is not the electricity conveyed but the medium which forms its vehicle.

On p. 16 the phenomena of induction of currents are hardly “described with due precision.” It is stated that “if there be a magnetic field, and a conductor in that field, any change in that field will produce the conditions that determine a current in that conductor.” No doubt it is stated immediately afterwards that, “if a conductor forming part of a closed circuit be moved *across* a magnetic field in a direction at right angles to the lines of

force in that field, a current will be induced whose strength is proportional to the strength of the field and to the rate at which the conductor cuts across the lines of force,” but it nowhere appears that a change of the magnetic induction through the circuit is the one determining condition of an induced current. The authors, indeed, as if to sum the matter up, conclude this passage with the unqualified statement, which, as it stands, is not true except under certain conditions which are not stated: “In fact, currents are produced in a closed circuit placed in a magnetic field, whenever any change whatever occurs in the intensity of that field.” If the circuit be so placed in the field that there is zero magnetic induction through it the field may be absolutely annulled without producing any current whatever.

Again, on p. 18 it is stated that “the energy of the current in a coil at any moment is expressed by the product of the electromotive force (E) at the terminals of the coil producing the current, and the current itself (C), that is, $W = EC$.” Now, what is here called the “energy of the current” is in reality the *activity* or time-rate of working of the current. The energy of the current at any instant is the energy which would be evolved in the form of a spark, or otherwise, if the current in the circuit were at that instant annulled. It is just this kind of misuse of the word energy that has led to the popular confusion (very common among the so-called “practical” (!) men who have applauded the Quixotic crusade against theory and “theoreticians”) between work and rate of working, and to the astounding proposition, not yet exploded in all quarters, that the efficiency of a motor is a maximum when half the whole energy spent is wasted.

There are various other points and some omissions in the introductory and theoretical portions which we had noted. The remarks on self-induction might be improved, and it would have been well to point out here that conductors carrying rapidly-alternating currents (and telephone wires certainly do this) have, as Lord Rayleigh has shown, a virtually increased resistance due to the concentration of the current in the outer part of the wire. Another point is the apparently unguarded application, made at pp. 123, 124, of the results of the theory of a slowly worked submarine cable to the transmission of the rapidly alternating currents of telephones. The state of the case is much less simple than the authors here make it appear. Also, it is not possible, with any approach to accuracy, to regard copper wires, in this connection, as “virtually free from electro-magnetic inertia.” But we have said enough as to these blemishes. They can be removed by careful extension and rewriting of the introduction. After all, it ought to be recognized that it is impossible to give in a book on a branch of electro-technics any statement of theory which can supersede that full and detailed treatment which is indispensable, and which must be sought in systematic treatises on electrodynamics.

As to the more purely technical portion of the work, we have only to repeat that it is full and trustworthy, and, moreover, remarkably well illustrated. There are several statements made by the authors which might be questioned, but as these are in many cases matters of opinion rather than of actual fact, we need not enter into them.

In conclusion, we have to say that this book is a

striking testimony to the rapid development of telephony. Thirteen years ago the first rude model of a telephone was brought from America by Sir William Thomson. One year later, Graham Bell himself brought to Scotland and exhibited first in Glasgow, and Mr. Preece brought to England, the telephone receiver (then also used as transmitter), almost exactly as it is now constructed. But a vast amount of practical work of a most important kind remained to be done before telephony could be made a commercial success. Without, however, waiting for this to be accomplished, a telephone line was immediately installed by Sir William Thomson between his house at the University and his laboratory, and between both and the workshop of his instrument-maker, Mr. White, in Sauchiehall Street, and this (now merged in the Telephone Exchange) has been in daily use ever since. From this very appropriate first practical beginning has developed the present immense and continually extending system, whose wires form a network above all our great cities, which plays so great a part in the transaction of business, and even of ordinary domestic affairs, and which now enables men in different cities at great distances apart to converse with one another by the living voice. All this has taken place in little more than ten years. Who knows what scientific wonders we may not see before A.D. 1900? But it is mournful to reflect that, as the applications of a scientific principle or invention become more and more wonderful, the thing itself excites so little interest among the people at large who continually use it. This is, no doubt, in part due to our curiosity- and admiration-stifling systems of education, and in part to other causes, about which it is useless to speculate. But true it is, "Familiarity breeds contempt," and, by the ordinary member of the British public, the telephone will soon be as much used, quite as little understood, and regarded with just as little curiosity, as the wonderful machine which he carries in his pocket from his boyhood to the end of his life.

A. GRAY.

OUR BOOK SHELF.

Morocco. By H. M. P. de la Martinière, F.R.G.S. (London: Whittaker and Co., 1889.)

In this book, which has been translated directly from the author's manuscript, M. de la Martinière records the impressions produced upon him during journeys in the kingdom of Fez, and to the Court of Mulai Hassan. He had exceptional opportunities of making himself acquainted with the facts of social life in Morocco; and in a simple, graphic, and clever narrative he describes exactly what he saw, and the inferences that may be reasonably drawn from his observations. Upon the whole, his account of the condition of the people is most unfavourable, and everyone who studies the evidence he brings forward will admit that the regeneration of Morocco, by whomsoever or in whatever way it may be undertaken, will be no easy task. One of the few bright spots in the author's picture is a passage in which he praises what he calls the refined taste of the Arabs of Morocco. This reveals itself in the industrial products of the country, in the decoration of the pavements and ceilings of their houses, and in the skill with which they match colours in dress. They by no means display the same aptitude for science, which is generally regarded, from a religious point of view, as a forbidden subject. On the other hand, alchemy flourishes, and M. de la Martinière says there are many rogues who

trade upon the credulity of the public. Some good route-maps and plans illustrate the text, and a preface is contributed by Colonel Trotter.

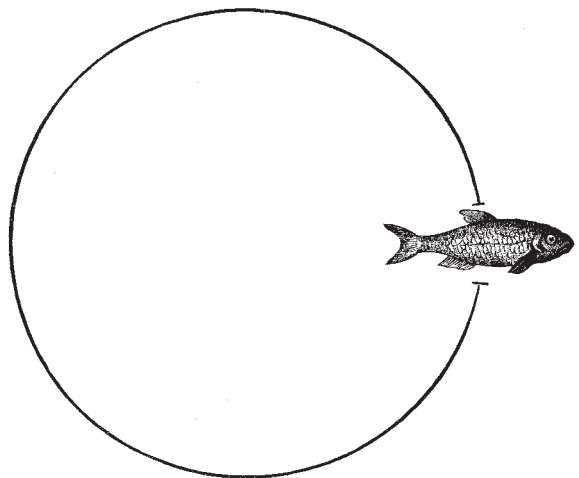
LETTERS TO THE EDITOR.

[The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of NATURE. No notice is taken of anonymous communications.]

The "Hatchery" of the Sun-fish.

I HAVE thought that an example of the intelligence (instinct?) of a class of fish which has come under my observation during my excursions into the Adirondack region of New York State, might possibly be of interest to your readers, especially as I am not aware that anyone except myself has noticed it, or, at least, has given it publicity.

The female sun-fish (called, I believe, in England, the roach or bream) makes a "hatchery" for her eggs in this wise. Selecting a spot near the banks of the numerous lakes in which this region abounds, and where the water is about 4 inches deep, and still, she builds, with her tail and snout, a circular embankment 3 inches in height and 2 thick. The circle, which is as perfect a one as could be formed with mathematical instruments, is usually a foot and a half in diameter; and at one side of this circular wall an opening is left by the fish of just sufficient width to admit her body, thus:—



The mother sun-fish, having now built or provided her "hatchery," deposits her spawn within the circular inclosure, and mounts guard at the entrance until the fry are hatched out and are sufficiently large to take charge of themselves. As the embankment, moreover, is built up to the surface of the water, no enemy can very easily obtain an entrance within the inclosure from the top; while there being only one entrance, the fish is able, with comparative ease, to keep out all intruders.

I have, as I say, noticed this beautiful instinct of the sun-fish for the perpetuity of her species more particularly in the lakes of this region; but doubtless the same habit is common to these fish in other waters.

WILLIAM L. STONE.

Jersey City Heights, N.J., U.S.A., May 30.

Black Rain.

ON Friday, April 12 last, the rain is stated to have come down black during a thunderstorm at places distributed over a considerable area in the County of Galway, King's County, and County of Tipperary.

I was in England at the time, and after my return to Ireland, on hearing of the rain-water being black in the tanks at a friend's house, I was at first sceptical as to its origin, as a heavy shower after a spell of tolerably dry weather might have brought down much dirt from the roofs, and hence I missed several opportunities of obtaining samples at once.